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(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

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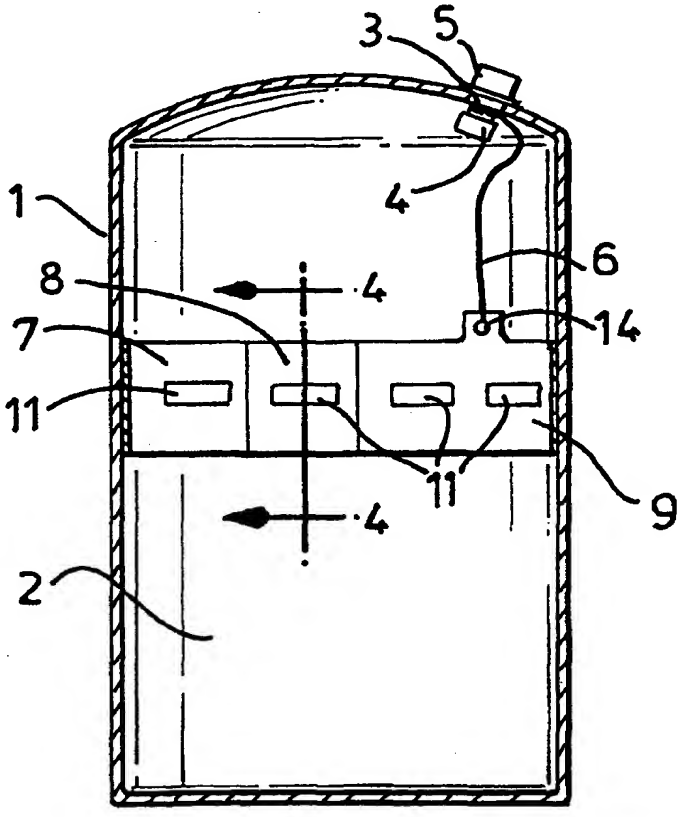
With international search report.

(54) Title: MONITORING SYSTEM

(57) Abstract

A sensor array for mounting within a vessel to enable conditions within the vessel to be monitored. An array of sensors is supported on a sheet which in use is mounted within the vessel, the sheet carrying the array of sensors and conductors connecting the sensors to an output through which signals may be transmitted, those signals being representative of conditions to which the sensors are exposed within the vessel. The output may be connected to a first monitoring unit located within the vessel. A second monitoring unit may be located outside the vessel, the first monitoring unit converting the sensor output signals into transmission signals which are transmissible through the vessel wall to the second monitoring unit to enable the second monitoring unit to output data representative of conditions within the vessel.



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MONITORING SYSTEM

The present invention relates to a system for monitoring conditions within a vessel a wall of which defines an enclosed space and a sensor array for mounting within such a vessel.

Process tomography systems have been designed which can obtain valuable information about process conditions within vessels. In many situations however it is undesirable or unacceptable to penetrate a process vessel with cables to enable communication with sensors located within that vessel. Typical situations in which such restrictions apply are stirred tank reactors, fluidised beds, separators, cyclones, hydraulic and pneumatic conveyors, crystallisers and the like. Particularly in the case of bioreactors where sterility is an essential requirement, or pharmaceutical manufacturing where high integrity containment is required to guarantee an uncontaminated workplace and product, it is highly undesirable to have cables penetrating the walls of process vessels.

Typical tomography systems require a symmetrically distributed set of transducers from which sample data produces a set of "projections" through the process. These are then "reconstructed" to form an estimate of the cross-section interrogated by the sensor array in terms of the parameters sensed by the transducers. A range of process information may then be estimated, for example volume fraction in a flowing mixture, solids concentration in stirred reactors, density distribution in a product and the like.

Typically transducers are arranged either singly or in pairs or in groups to measure a range of parameters. Examples are electrical capacitance measuring systems, electrical resistance measuring systems, electromagnetic inductance measuring systems, acoustic and ultrasound reflection and transmission measuring systems, X-ray transmission measuring systems, and nuclear magnetic resonance measuring systems. In some processes two or more types of transducers are used in order to gain sensitivity to a range of materials within the process. Such applications are typically described as multi-modal tomography applications.

When a set of distributed transducers is used it is desirable that each transducer comes into close contact with or proximity to the process at a particular

geometric position. In a simple case each transducer may make such contact through a hole or opening formed at an appropriate location in a process vessel wall. Although such an approach is simple and direct and can readily be used for experimental purposes and may be viable in some practical circumstances, there are also many situations in which such penetration of a vessel wall is undesirable.

A further problem which can be encountered when seeking to fit tomographic sensors within a process vessel is that of appropriately positioning sensors on the inside of a process vessel wall, particularly in situations where it is inappropriate to make connections to the sensors directly through that wall. There are also applications in which the process vessel includes mechanical structures such as stirrers which prevent the surface mounting of bulky sensor assemblies on the process vessel wall. This makes it very difficult in many circumstances for tomography sensors to be retro-fitted to existing process vessels.

It is an object of the present invention to obviate or mitigate some or all of the problems outlined above.

The present invention provides a sensor array for mounting within a vessel to enable conditions within the vessel to be monitored, comprising a sheet which may be mounted on a support within the vessel, the sheet carrying an array of sensors and conductors connecting the sensors to at least one output through which signals may be transmitted which are representative of conditions to which the sensors are exposed.

The invention as defined in the preceding paragraph makes it possible to readily position sensors suitable for connection to for example a tomographic imaging system inside a process vessel without requiring significant clearance above the original process vessel wall surface, the relative positioning of different components of the sensor array being determined by the position of the components on the sheet.

The sheet may be a laminar construction with the conductors defined by conductive tracks deposited on an insulating substrate. Alternatively, the conductors may be defined by conductive elements supported within the sheet.

The conductive tracks may be covered with an electrically insulating layer, and the sensors may also be covered with the electrically insulating layer.

The sheet may be flexible.

The sheet may comprise a series of sections which are interconnected such that at least some of the conductive tracks extend across the interconnections between the sections

According to the present invention, there is also provided a system for monitoring conditions within a vessel a wall of which defines an enclosed space, comprising a plurality of sensors which in use are distributed within the vessel, a first monitoring unit located within the vessel and connected to each of the sensors, and a second monitoring unit located outside the vessel, the first monitoring unit comprising means for converting sensor output signals into transmission signals which are transmissible through the vessel wall, and the second monitoring unit comprising means for detecting the transmission signals outside the vessel wall and deriving data representative of conditions within the vessel from the transmission signals.

The invention as defined above makes it possible to avoid penetrating a process vessel wall with any cables even in the event that for example a tomographic sensing system incorporates a large number of sensors.

Preferably, means are provided for transmitting a power signal from outside the vessel to the first monitoring unit, the first monitoring unit comprising a detector arranged to detect the power signal and a power supply energised by the detected power signal.

The first monitoring unit may comprise an antenna and an associated detector circuit tuned to a predetermined frequency, and the power signal may be transmitted at the predetermined frequency.

The vessel may incorporate a window, and the first monitoring unit may be arranged to transmit optical transmission signals through the window to the second monitoring unit. The first monitoring unit may comprise a laser to generate the optical transmission signals. The optical signals may be infra-red signals.

The transmission signals may be radio telemetry signals to which at least a part of the vessel wall is transparent.

Referring to the accompanying drawings, an embodiment of the present invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a vertical section through a process vessel incorporating a tomographic sensing system in accordance with the present invention;

Figure 2 is a plan view of a flexible sheet supporting a single electrode which is incorporated in the process vessel of Figure 1;

Figure 3 is a plan view of part of a further sheet carrying two electrodes also incorporated in the process vessel of Figure 1; and

Figure 4 is a section on the line 4-4 of Figure 2.

Referring to Figure 1, the illustrated process vessel has a wall 1 which completely encloses a space 2 within which for example a fermentation process is to be carried out. The vessel 1 has a steel wall in which a glass window 3 is provided, such windows being commonplace in process vessels to enable a visual inspection of the vessel contents. A first monitoring unit 4 is secured to the inside surface of the window 4 and a second monitoring unit 5 is secured to the outside surface of the window 4.

The first monitoring unit 4 is connected by a multi-way cable 6 to an electrode assembly which extends around the inner surface of the process vessel. The electrode assembly is made up of a series of units three of which are shown in Figure 1, that is units 7, 8 and 9. Each of the units is in the form of a flexible sheet adhered to the inner surface of the process vessel, the units being interconnected end to end. Figure 2 is a plan view of a sheet which can be used as the unit 7 or 8 in Figure 1. Figure 3 is a plan view of a sheet which can form the unit 9 of Figure 1. Figure 4 is a section through the sheet of Figure 2 in the direction of lines 4-4 in Figure 2.

Referring to Figures 2 and 4, the illustrated unit comprises a flexible electrically insulating substrate 10 upon which a copper electrode 11 and a series of conductive tracks 12 have been printed. An insulating layer 13 covers the conductive tracks 12 but does not cover the surface of the electrode 11 which is on the far side of the substrate 10 from the vessel wall 1. Accordingly resistance measurements may be made between any one electrode and one or more of the other electrodes in the array which are spaced around the process vessel. Each of the electrodes 11 is connected by a respective pair of tracks 12 to a terminal in a terminal array 14 provided on the electrode unit 9 (Figure 3). Each of those terminals is in turn connected by the cable 6 to the first monitoring unit 4.

Data derived from the electrodes 11 is optically coupled through the window 3 to the second monitoring device 5. The signals coupled through the window 3 may simply directly represent outputs derived from the electrodes 11, or those outputs may be processed in the first monitoring unit 4 before transmission to the second monitoring unit 5. Thus large amounts of data may be picked up by the electrode array and transmitted to the exterior of the process vessel without it being necessary for the process vessel wall to be penetrated in any way. In the event that the process vessel has to be sterilised between processing operations the electrode array is robust and can be readily cleaned.

Given that the electrodes 11 are mounted on an insulating substrate 10 which extends to a substantial distance away from the edges of the electrodes 11, electrical fields which can be generated within a process fluid within the process vessel are not shorted out to the process vessel wall at positions close to the electrodes. Thus electrical fields emanating from the electrodes 11 can extend a substantial distance into the body of the fluid contained by the vessel. Useful data can be obtained using conventional resistance tomography techniques.

Electrode arrays may be made up from a number of the individual units such as those illustrated in Figures 2 and 3 so as to make it possible to fit electrode arrays in process vessels of different sizes using essentially standard components. Individual electrode array units may be connected end to end using the end-connectors shown in Figures 2 and 3. The electrode arrays are thin and therefore can be readily shaped so as to be adhered closely to the walls of a process vessel, enabling their use in applications where the electrode arrays cannot project substantially from the internal wall of the vessel, for example when retro-fitting electrode arrays to vessels in which stirrers are provided which sweep across the inner surface of the vessel walls. It is a relatively easy matter to produce electrode assemblies with an installed thickness of less than one millimetre.

In the illustrated case, the electrodes 11 are not insulated from the process fluids. This is appropriate in the case of an electrode array used for resistance measurements. Other tomographic configurations are however possible, for example systems based on capacitance measurement. In the case of a system used for

capacitance measurements, the electrodes 11 may or may not be covered by the insulating layer 13.

Although in the illustrated case communication between the interior and exterior of the vessel is achieved through a window 3, it will be appreciated that the cable 6 could be fed through a suitably sealed opening in the process vessel wall, thereby enabling a direct connection to be made between the electrodes and the external monitoring unit 5.

In the case illustrated in Figure 1, it is necessary to energise the first monitoring unit 4. This could be achieved using a suitable battery-energised power pack but this would require periodic replacement of the battery. In an alternative arrangement the first monitoring unit 4 may be energised using a remote link relying upon for example inducing electrical energy by transmitting a power signal from the second monitoring unit to the first, the first monitoring unit being provided with an antenna and a detector tuned to detect the power signal, and the detector providing an output to an appropriate power supply.

In the case illustrated in Figure 1, data is transferred between the first and second monitoring units using an optical link, for example relying upon a laser or other simple optical transmission and reception systems. Other non-contact telemetry options are available however, for example infra-red systems and radio telemetry links.

In the illustrated case, the sensor array is supported on the inside surface of a side wall of a vessel. It will be appreciated that the sensor array could be mounted at any appropriate position in the process vessel, including the top wall, the bottom wall or floor, or on a support surface within the vessel, for example on an impeller blade of a stirrer assembly or a support base of a filter which does not itself form part of the containment wall.

In the illustrated case, the sheet is a laminar structure with the conducting electrodes and connections deposited on an insulating substrate. Other structures are possible, for example a filter cloth in which the cloth supports the conducting electrodes and connections on a suitably insulating substrate, or the electrodes and connections are deposited directly on the cloth e.g. by painting, or the electrodes

and/or connections are incorporated as conductive elements or threads within the cloth.

CLAIMS

1. A sensor array for mounting within a vessel to enable conditions within the vessel to be monitored, comprising a sheet which may be mounted on a support within the vessel, the sheet carrying an array of sensors and conductors connecting the sensors to at least one output through which signals may be transmitted which are representative of conditions to which the sensors are exposed.

2. A sensor array according to claim 1, wherein the sheet is laminar and the conductors are defined by conductive tracks deposited on an insulating substrate.

3. A sensor array according to claim 1, wherein the sheet comprises interengaged elongate elements and the conductors are defined by conductive elements within the sheet, the conductive elements being supported by non-conductive elements within the sheet.

4. A sensor array according to claim 2 or 3, wherein the conductive tracks are covered by an electrically insulating layer.

5. A sensor array according to claim 4, wherein the sensors are covered by the electrically insulating layer.

6. A sensor array according to any one of claims 1 to 5, wherein the sheet is flexible.

7. A sensor array according to any one of claims 1 to 4, wherein the sheet comprises a series of sections which are interconnected such that at least some of the conductors extend across the interconnections between the sections.

8. A system for monitoring conditions within a vessel a wall of which defines an enclosed space, comprising a sensor array in accordance with any preceding claim, wherein the sensors are distributed within the vessel, a first monitoring unit is located

within the vessel and connected to each of the sensors, and a second monitoring unit is located outside the vessel, the first monitoring unit comprising means for converting sensor output signals into transmission signals which are transmissible through the vessel wall, and the second monitoring unit comprising means for detecting the transmission signals outside the vessel walls and deriving data representative of conditions within the vessel from the transmission signals.

9. A system according to claim 8, wherein means are provided for transmitting a power signal from outside the vessel to the first monitoring unit, the first monitoring unit comprising a detector arranged to detect the power signal and a power supply energised by the detected power signal.

10. A system according to claim 9, wherein the first monitoring unit comprises an antenna and an associated detector circuit tuned to a predetermined frequency, and a power signal is transmitted at the predetermined frequency.

11. A system according to any one of claims 8 to 10, wherein the vessel incorporates a window, and the first monitoring unit is arranged to transmit optical transmission signals through the window to the second monitoring unit.

12. A system according to claim 11, wherein the first monitoring unit comprises a laser to generate the optical transmission signals.

13. A system according to claim 11 or 12, wherein the optical transmission signals are infra-red signals.

14. A system according to claim 8, 9 or 10, wherein the transmission signals are radio telemetry signals to which at least a part of the vessel wall is transparent.

15. A system for monitoring conditions within a vessel a wall of which defines an enclosed space, comprising a plurality of sensors which in use are distributed within the vessel, a first monitoring unit located within the vessel and connected to each of

the sensors, and a second monitoring unit located outside the vessel, the first monitoring unit comprising means for converting sensor output signals into transmission signals which are transmissible through the vessel wall, and the second monitoring unit comprising means for detecting the transmission signals outside the vessel walls and deriving data representative of conditions within the vessel from the transmission signals.

16. A system according to claim 15, wherein means are provided for transmitting a power signal from outside the vessel to the first monitoring unit, the first monitoring unit comprising a detector arranged to detect the power signal and a power supply energised by the detected power signal.

17. A system according to claim 16, wherein the first monitoring unit comprises an antenna and an associated detector circuit tuned to a predetermined frequency, and a power signal is transmitted at the predetermined frequency.

18. A system according to any one of claims 15 to 17, wherein the vessel incorporates a window, and the first monitoring unit is arranged to transmit optical transmission signals through the window to the second monitoring unit.

19. A system according to claim 18, wherein the first monitoring unit comprises a laser to generate the optical transmission signals.

20. A system according to claim 18 or 19, wherein the optical transmission signals are infra-red signals.

21. A system according to claim 15, 16 or 17, wherein the transmission signals are radio telemetry signals to which at least a part of the vessel wall is transparent.

22. A system according to any one of claims 15 to 21, wherein the plurality of sensors are carried by a sheet which is secured on the inside face of the vessel wall,

the sensors being connected to the first monitoring unit by conductive tracks formed on the sheet.

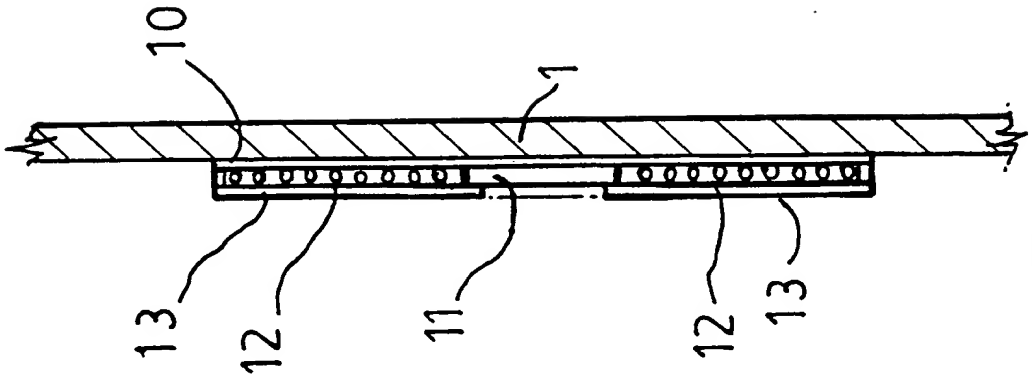

FIG. 4

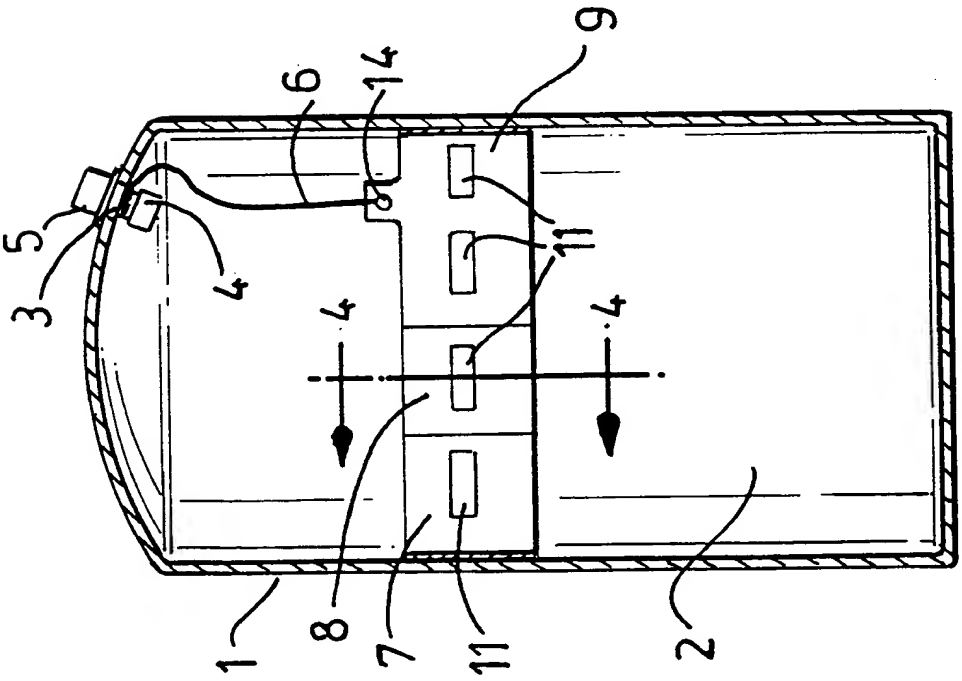

FIG. 1

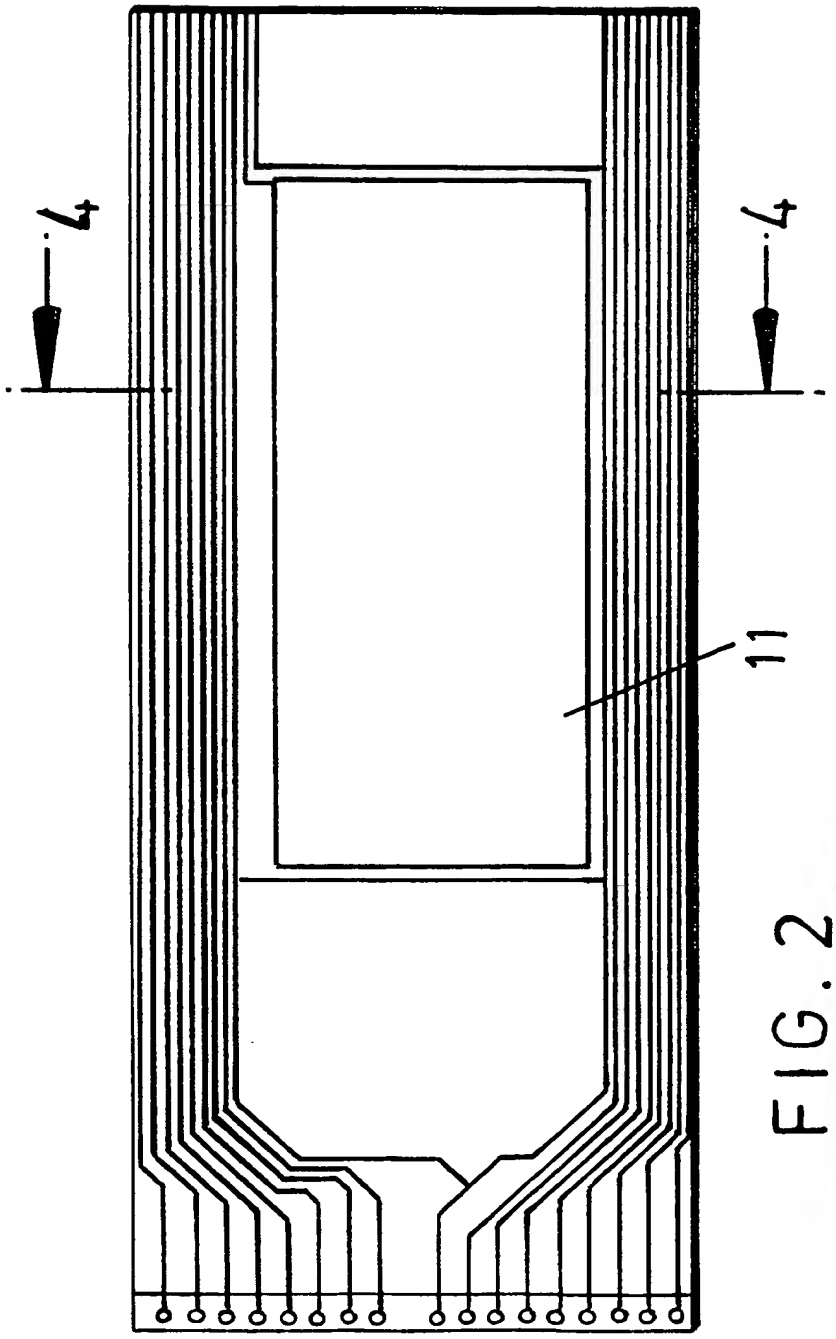

FIG. 2

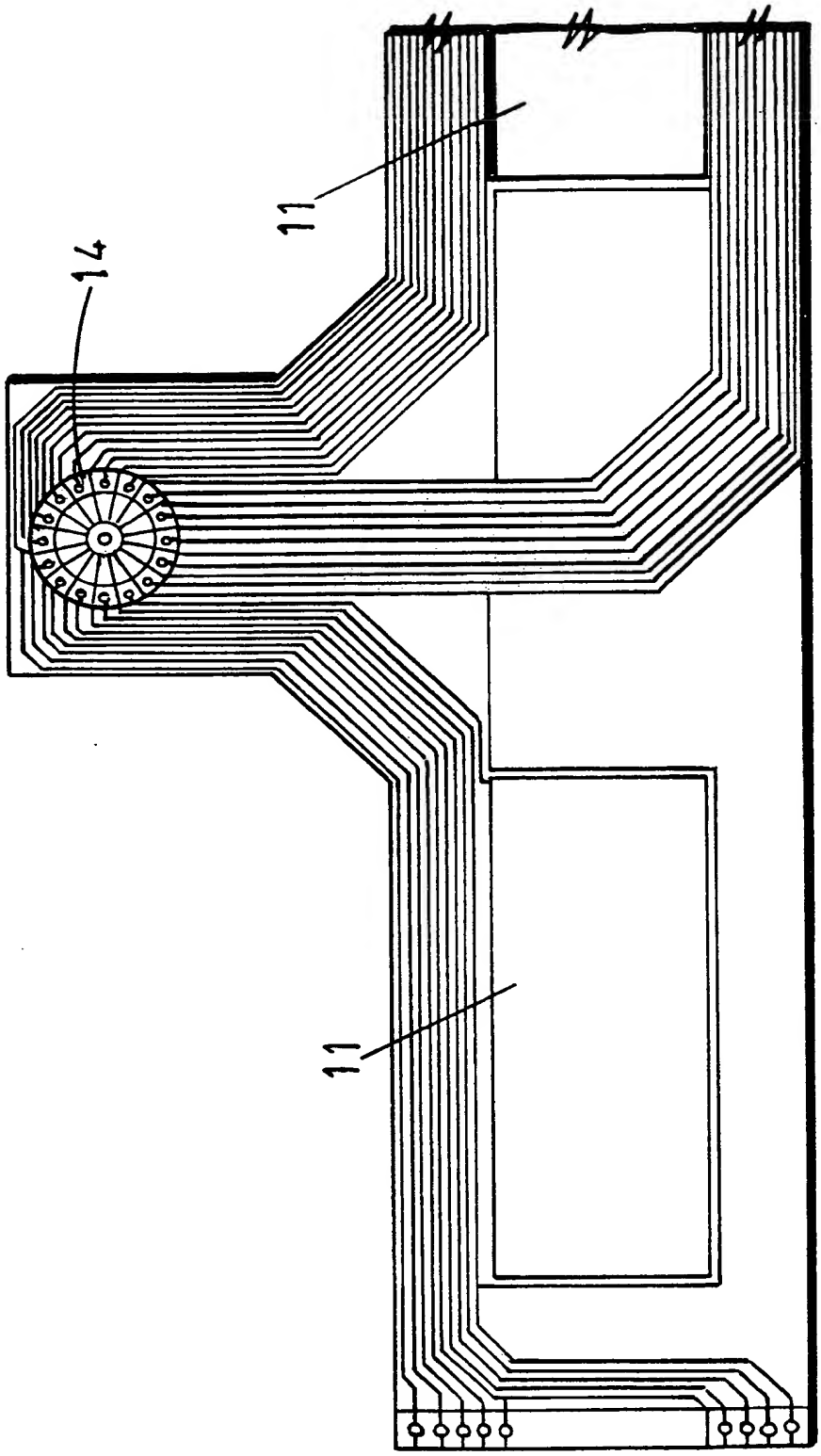

FIG. 3

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

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NOTIFICATION OF ELECTION

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To:

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Date of mailing (day/month/year) 17 July 2000 (17.07.00)	
International application No. PCT/GB99/03709	**Applicant's or agent's file reference** PJA/C088284PWO
International filing date (day/month/year) 10 November 1999 (10.11.99)	**Priority date** (day/month/year) 11 November 1998 (11.11.98)
Applicant HOYLE, Brian, Stewart et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

09 June 2000 (09.06.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

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PATENT COOPERATION TREATY

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INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
PJA/C088284PWO		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/GB 99/ 03709	10/11/1999	11/11/1998
Applicant		
PROCESS TOMOGRAPHY FORESIGHT TECHNOLOGY Ltd et al		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

   [ ] as suggested by the applicant.

   [X] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/03709

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01D11/24 G08C23/04 G08C17/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01D G08C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 5 832 592 A (STASZ PETER ET AL) 10 November 1998 (1998-11-10) the whole document ---	1-7 8-14,22
X Y	PATENT ABSTRACTS OF JAPAN vol. 1997, no. 01, 31 January 1997 (1997-01-31) & JP 08 233845 A (TOKYO GAS CO LTD), 13 September 1996 (1996-09-13) abstract ---	1-7 8-14,22
X Y	DE 39 20 207 A (ENDRESS HAUSER GMBH CO) 10 January 1991 (1991-01-10) claims --- -/--	15,16,18 8,9,11, 19-22

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 February 2000	23/02/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Lloyd, P

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/03709

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0 511 807 A (IND ELECTRONIC AUTOMATION LTD ;GEC AVERY LTD (GB)) 4 November 1992 (1992-11-04) abstract	10,14, 17,21
Y	US 3 713 124 A (DURLAND D ET AL) 23 January 1973 (1973-01-23) abstract	10,14, 17,21
Y	US 4 857 727 A (LENZ JAMES E ET AL) 15 August 1989 (1989-08-15) abstract	11-13, 19,20

1

INTERNATIONAL SEARCH REPORT

[redacted]mation on patent family members

[redacted]ernational Application No
PCT/GB 99/03709

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5832592 A	10-11-1998	US 5161541 A	10-11-1992
		US 5558099 A	24-09-1996
JP 08233845 A	13-09-1996	NONE	
DE 3920207 A	10-01-1991	NONE	
EP 0511807 A	04-11-1992	CA 2108643 A,C	19-04-1995
		GB 2255188 A,B	28-10-1992
		US 5332315 A	26-07-1995
US 3713124 A	23-01-1973	CA 938677 A	18-12-1973
		DE 2134731 A	20-01-1972
		GB 1343689 A	16-01-1974
		JP 52031176 B	12-08-1977
US 4857727 A	15-08-1989	JP 2057020 A	26-02-1990

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REC'D 15 FEB 2001
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PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
JA/C088284PWO		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB99/03709	10/11/1999	11/11/1998
International Patent Classification (IPC) or national classification and IPC G01D11/24		
Applicant PROCESS TOMOGRAPHY FORESIGHT TECHNOLOGY Ltd et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 2 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
09/06/2000	12.02.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Koeck, A Telephone No. +49 89 2399 2493

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB99/03709

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*:
Description, pages:

1,3-7	as published			
2	as received on	29/01/2001	with letter of	29/01/2001

Claims, No.:

8 (part),9-22	as published			
1-7,8 (part)	as received on	29/01/2001	with letter of	29/01/2001

Drawings, sheets:

1/3-3/3	as published

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:
   ☐ the claims, Nos.:
   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

   ☐ the entire international application.

   ☒ claims Nos. 15-22.

because:

   ☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):

   ☒ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. 15-22 are so unclear that no meaningful opinion could be formed (*specify*):
   see separate sheet

   ☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

   ☐ no international search report has been established for the said claims Nos. .

2. A meaningful international preliminary examination report cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

   ☐ the written form has not been furnished or does not comply with the standard.
   ☐ the computer readable form has not been furnished or does not comply with the standard.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability;

citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	
	No:	Claims	1
Inventive step (IS)	Yes:	Claims	
	No:	Claims	2-14
Industrial applicability (IA)	Yes:	Claims	1-22
	No:	Claims	

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

III Non-establishment of opinion

1. The various definitions of the invention given in independent claims 1 and 15 are such that the claims as a whole are not clear and concise, contrary to Article 6 PCT. The claims should be recast to include only the minimum necessary number of independent claims in any one category, with dependent claims as appropriate (Rule 6.4(a)-(c) PCT). In the present case it is considered appropriate to use only one independent claim. Claims 15 - 22 are thus not examined.

V. Reasoned statement under Article 35(2) PCT

1. The following documents have been considered for the purposes of this report:

D1 = US-A-5 832 592
D2 = JP 08 233845 A
D3 = EP-A-0 511 807
D4 = EP-A-0 326 266 (cited by applicant in fax dated 29.01.2001)

2. Article 33(2) (novelty)

A tomographic sensor array is known from D4, Fig. 1, cl. 1, suitable for mounting on a support within a vessel to enable conditions within the vessel remote from that support to be monitored (cl. 1, L. 24 - 27), comprising a sheet carrying an array of sensors and conductors (Fig. 1, (1-8)) connecting the sensors to at least one output through which signals may be transmitted which are representative of conditions within the vessel (Fig. 1, output from (15)).

The present application does thus not satisfy the criterion set forth in Article 33(2) PCT because the subject-matter of claim 1 is not new in respect of prior art as defined in the regulations (Rule 64(1)-(3) PCT).

3. Article 33(3) PCT (inventive step)

The dependent claims 2 - 14 are merely simple and routine features that the skilled man would include in an information display system, their subject-matter

thus lacking an inventive step, see documents D4, D1, D2 and D3 all of which disclose a sensor array according to the present claim 1 for monitoring conditions within a vessel (D1, Fig. 1, cl. 1; D2, Fig.; D3, Fig. 2).

The present application does not satisfy the criterion set forth in Article 33(3) PCT because the subject-matter of claims 2 - 14 does not involve an inventive step (Rule 65(1)(2) PCT).

4. Industrial applicability

The claimed array may be used to monitor conditions within a vessel.

VII Certain defects in the international application

1. The documents D1 - D4 have not been identified in the description nor has the relevant background art disclosed therein been discussed. The requirements of Rule 5.1(a)(ii) PCT are, thus, not fulfilled.

2. The independent claims should have been drafted in the two-part form as required by Rule 6.3(b) PCT, whereby the features known from D4 should have been placed in the preamble.

3. Reference signs in parentheses should have been inserted in the claims to increase their intelligibility, Rule 6.2(b) PCT. This apply to both the preamble and characterising portion.

CLAIMS

1. A sensor array for mounting within a vessel to enable conditions within the vessel to be monitored, comprising a sheet which may be mounted on a support within the vessel, the sheet carrying an array of sensors and conductors connecting the sensors to at least one output through which signals may be transmitted which are representative of conditions to which the sensors are exposed.

2. A sensor array according to claim 1, wherein the sheet is laminar and the conductors are defined by conductive tracks deposited on an insulating substrate.

3. A sensor array according to claim 1, wherein the sheet comprises interengaged elongate elements and the conductors are defined by conductive elements within the sheet, the conductive elements being supported by non-conductive elements within the sheet.

4. A sensor array according to claim 2 or 3, wherein the conductive tracks are covered by an electrically insulating layer.

5. A sensor array according to claim 4, wherein the sensors are covered by the electrically insulating layer.

6. A sensor array according to any one of claims 1 to 5, wherein the sheet is flexible.

7. A sensor array according to any one of claims 1 to 4, wherein the sheet comprises a series of sections which are interconnected such that at least some of the conductors extend across the interconnections between the sections.

8. A system for monitoring conditions within a vessel a wall of which defines an enclosed space, comprising a sensor array in accordance with any preceding claim, wherein the sensors are distributed within the vessel, a first monitoring unit is located

geometric position. In a simple case each transducer may make such contact through a hole or opening formed at an appropriate location in a process vessel wall. Although such an approach is simple and direct and can readily be used for experimental purposes and may be viable in some practical circumstances, there are also many situations in which such penetration of a vessel wall is undesirable.

A further problem which can be encountered when seeking to fit tomographic sensors within a process vessel is that of appropriately positioning sensors on the inside of a process vessel wall, particularly in situations where it is inappropriate to make connections to the sensors directly through that wall. There are also applications in which the process vessel includes mechanical structures such as stirrers which prevent the surface mounting of bulky sensor assemblies on the process vessel wall. This makes it very difficult in many circumstances for tomography sensors to be retro-fitted to existing process vessels.

It is an object of the present invention to obviate or mitigate some or all of the problems outlined above.

The present invention provides a sensor array for mounting within a vessel to enable conditions within the vessel to be monitored, comprising a sheet which may be mounted on a support within the vessel, the sheet carrying an array of sensors and conductors connecting the sensors to at least one output through which signals may be transmitted which are representative of conditions to which the sensors are exposed.

The invention as defined in the preceding paragraph makes it possible to readily position sensors suitable for connection to for example a tomographic imaging system inside a process vessel without requiring significant clearance above the original process vessel wall surface, the relative positioning of different components of the sensor array being determined by the position of the components on the sheet.

The sheet may be a laminar construction with the conductors defined by conductive tracks deposited on an insulating substrate. Alternatively, the conductors may be defined by conductive elements supported within the sheet.

The conductive tracks may be covered with an electrically insulating layer, and the sensors may also be covered with the electrically insulating layer.

The sheet may be flexible.

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

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MARKS & CLERK
Sussex House
83-85 Mosley Street
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GRANDE BRETAGNE

PCT

NOTIFICATION OF TRANSMITTAL OF
THE INTERNATIONAL PRELIMINARY
EXAMINATION REPORT
(PCT Rule 71.1)

Date of mailing *(day/month/year)*	12.02.2001

Applicant's or agent's file reference	IMPORTANT NOTIFICATION
JA/C088284PWO	

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB99/03709	10/11/1999	11/11/1998

Applicant
PROCESS TOMOGRAPHY FORESIGHT TECHNOLOGY Ltd et al

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

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Form PCT/IPEA/416 (July 1992)